DOCUMENT RESUME

ED 449 044 SE 064 546

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TITLE Effect of Gender, Achievement in Mathematics, and Ethnicity on Attitudes toward Mathematics.
PUB DATE 2000-11-16
NOTE 19p.; Paper presented at the Annual Meeting of the Mid-South Educational Research Association (Bowling Green, KY, November 15-17, 2000).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Bilingual Education; Foreign Countries; High Schools; *Mathematics Achievement; Mathematics Education; Measures (Individuals); *Sex Differences; *Student Attitudes

ABSTRACT

The effects of gender, math achievement, and ethnicity on attitudes toward mathematics were examined using an inventory called Attitudes toward Mathematics Instrument (ATMI). The inventory was completed by 545 students at a college preparatory bilingual school in Mexico City. Data were analyzed using a multivariate factorial model with four factors of Math Attitude as dependent variables (self-confidence, value, motivation, and enjoyment of mathematics) and three independent variables (gender, math achievement, and ethnicity). Multivariate analysis of variance was performed. There was an overall significant effect of gender on two of the factors of ATMI. Male students scored higher than female students on self-confidence and value. Letter grade was significant, with "A" students scoring higher than others on all four factors of the ATMI. A similar relationship of letter grade to factors was found in the hierarchy from "B" through "F" students. Failing students scored lowest on self-confidence, motivation, value, and enjoyment. There was an overall significant effect of ethnicity on three factors. Mexican students scored significantly higher than American students on self-confidence, value, and enjoyment. Students with dual citizenship--students who had one American parent--scored higher than Americans with no other citizenship on the value of mathematics. (Contains 30 references.) (ASK)

Running head: EFFECT OF GENDER, ACHIEVEMENT IN MATHEMATICS, AND ETHNICITY ON ATTITUDES TOWARD MATHEMATICS

EFFECT OF GENDER, ACHIEVEMENT IN MATHEMATICS, AND ETHNICITY ON ATTITUDES TOWARD MATHEMATICS

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Paper presented at the Annual Meeting of the
Mid-South Educational Research Association,
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November 15-17, 2000

ABSTRACT

The effects of gender, math achievement and ethnicity on attitudes toward mathematics were examined by use of an inventory called Attitudes Toward Mathematics Instrument (ATMI). The inventory was completed by 545 students at a college preparatory bilingual school in Mexico City and data were analyzed using a multivariate factorial model with four factors of Math Attitude as dependent variables (self-confidence, value, motivation, and enjoyment of mathematics) and three independent variables, gender, math achievement, and ethnicity. Multivariate analysis of variance was performed. There was an overall significant effect of gender on two of the factors of ATMI. Male students scored higher than female students on self-confidence and value. Letter grade was significant with A students scoring higher than others on all four factors of the ATMI. A similar relationship of letter grade to factors was found in the hierarchy from B through F students. Failing students were lowest on self-confidence, motivation, value, enjoyment. There was an overall significant effect for ethnicity on three factors. Mexican students scored significantly higher than American students on self-confidence, value, and enjoyment. Students with dual citizenship, where students had one American parent, scored higher than Americans on value of mathematics.

Effect of Gender, Achievement in Mathematics, and Ethnicity on Attitudes Toward Mathematics

Introduction

As the modern society has become increasingly dependent upon technology, science, and research, mathematics has become critical in the preparation of students for future careers and for the security and progress of the nation. There has been considerable concern about mathematics instruction since the "Space Race" of the 1950s, a concern has only increased in the last decade as we have entered a new technological age. Mathematics is continuously developing and becoming ever more specialized, which makes it more difficult to develop a curriculum that includes more students in K-12 education. Complicating this is disagreement about methodology across content domains, with some maintaining that content disciplines are unique and that teaching strategies must also be unique. The opposite view is that universal methods exist regardless of the content domain (Reigeluth, 1987). However, the most predominant approach in recent years, regardless of theoretical orientation of curriculum designers, is an emphasis on authentic or "real-world" applications. This is further complicated by professional disputes over constructivism versus direct instruction.

Today, classroom instruction is often a mixture of Skinnerian behaviorism and Piagetian or Vygotskyian epistemology influenced by postmodern and connectionist theories (Collins & Duguid, 1989; Bednar, Cunningham, Duffy, & Perry, 1991; Shepard, 1991; Hlynka & Belland, 1991; Clancey, 1992). The national standards for mathematics are predicated on the belief that students should engage in math activities that are relevant to daily

living. However, many educators and school patrons see this as a culmination rather than something intrinsic to math instruction. In recent years we have learned that children do not simply internalize what teachers tell them in classrooms. Students attempt to make sense of new information based on meanings they personally construct. And fundamental to all of this is the students' attitudes about mathematics.

Research shows that attitudes toward mathematics are extremely important in the achievement and participation of students in mathematics (Shashaani, 1995). Gallagher and De Lisi (1994) showed a positive relationship between performance on standardized mathematics tests and positive attitudes toward mathematics. Attitudes can predict final mathematics course grade and are correlated with continuation in advanced mathematics courses once enrollment becomes optional (Thorndike-Christ, 1991).

Due to the social context and other intervening variables, differences in attitudes exist by gender, ethnicity, cultural background, and instructional methods (Murphy & Ross, 1990; Hollowell & Duch 1991; Huang, 1993; Leder, 1994). Recognizing the importance of attitudes, there is an increasing awareness of the need to examine attitudes and consider possible methods of intervention. The development of a positive attitude toward subject matter is probably one of the most prevalent educational goals.

Previous Research

Math anxiety is directly related to previous school mathematics performance as well as the attitudes developed during those prior mathematical experiences (Hauge, 1991). Terwilliger and Titus (1995) reported attitudes are inversely related to math anxiety. Nearly as many students who decide to major in science, mathematics, or engineering after their sophomore year of college as high school sophomores with similar intentions, indicating that

attitudes can be affected (Hoffer, 1993). It is clear that knowledge about the importance of math is important, as reported in The Longitudinal Study of American Youth (1991), which showed that 28 percent of all seniors who were not enrolled in a mathematics or science course did not believe advanced mathematics was required for their future plans. Of the 12th-grade students who planned to become scientists, less than two-thirds believed they needed specific advanced mathematics in high school. Among 8th-grade students, 57 percent said they looked forward to mathematics classes; 90 percent believed mathematics to be important to their futures.

Self-confidence or self-efficacy is a good predictor of success in mathematics (Goolsby, 1988; Randhawa et al. , 1993)). Changes at the affective and achievement levels have more effect on participation in mathematics that those aimed at cognitive levels (Linn & Hyde, 1989). Clearly, the support and actions of parents and teachers are critical in shaping attitudes (Kenschaft, 1991; Dossey, 1992; Chang, 1990

Attitudes toward mathematics may be related to achievement and ability in mathematics but not to temperament or other personality variables (Dwyer, 1993). Teachers' attitudes are significantly related to student attitudes but not to achievement, but the effect of teachers' attitudes on students' attitudes is cumulative. Students make higher achievement gains if they had a sequence of 3 teachers with favorable attitudes towards mathematics.

The cultural context is important in creating gender differences (American Association of University Women, 1992; Hanson, 1992; Gill, 1994). Students stereotype careers by gender and consider science professions to be for males; however, neither boys nor girls are aware of the importance of math and science in careers (Pettitt, 1995.). Stipek and Granlinski (1991) found that girls tend to believe that females are inferior in math and that poor

performance is because of a lack of ability instead of lack of effort. While the literature shows that attitudes toward mathematics are important, there is a paucity of research about the different factors that influence the attitudes toward mathematics or an understanding of how and why they change over time.

Method

Subjects

The subjects were 545 high school students from a private, bilingual college preparatory school in Mexico City, Mexico, accredited by The Southern Association of Colleges and Schools. The high school has approximately 720 students; each grade has approximately 180 students. The students are bilingual, speaking English and Spanish. The school population consists of Mexicans, Mexican-American (born in Mexico with at least one American parent), Americans (children with parents working for international companies of for the United States Embassy), and other nationalities (children with parents working for international companies or different embassies). Most of the students were from high-income families. Three hundred two subjects were boys and 243 subjects were girls from all four grades (9-12) of high school. The subjects were enrolled in classes conducted by seven mathematics high school teachers. Only students taking mathematics were included in the sample. Intact classes were used in the sample.

Of the 302 boys, 58 were freshmen, 99 were sophomores, 98 were juniors, and 43 were seniors in high school. Four of the boys were in 8th grade but were taking mathematics classes in the high school. Fifty-one percent of the boys were Mexican, 13% were American, 15% had dual citizenship (having one American parent), 7% were from Latin American countries, 2% were Europeans, 6% were Asian, and 5% reported other nationalities. Four of

the boys did not report their ethnic background. Of the 243 girls, 77 were freshmen, 54 were sophomores, 70 were juniors, and 41 were seniors in high school. One girl was in 8th grade. Fifty-three percent of the girls were Mexican, 16% were American, 13% had dual citizenship (having one American parent), 7% were from Latin American countries, 1% were Europeans, 4% were Asian, and 4% reported other nationalities. Two of the girls did not report their ethnic background.

Materials

The Attitudes Toward Mathematics Inventory (ATMI) is a 40-item scale. The items were constructed using a Likert-format scale of five alternatives for the responses with anchors of 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, and 5: strongly agree. Eleven items of this instrument were reversed items. These items were given the appropriate value for the data analysis. The score was the sum of the ratings.

A Student's Demographic Questionnaire was also used. This questionnaire consisted of five questions. The purpose of these questions was for identifying the gender, grade level, current grade in mathematics, and nationality-ethnic background of the student.

Procedure

The mathematics teachers administered the ATMI and the Student's Demographic Questionnaire to the subjects during their classes. Directions were provided in written form, and students recorded their responses on computer scannable answer sheets.

Results

Tapia and Marsh (2000) found a four-factor solution from an exploratory factor analysis with maximum likelihood method of extraction and a varimax, orthogonal, rotation. The names for the factors reported in Tapia and Marsh (2000) were Self-confidence, Value of

Mathematics, Enjoyment of Mathematics, and Motivation. Based on that factor analysis, the 40 items were classified into four categories each of which was represented by a factor. A composite score for each category was calculated by adding up all the numbers of the scaled responses to the items belonging to that category.

The data were analyzed by using multivariate factorial model with the four factors as dependent variables: (1) Self-confidence , (2) Value, (3) Enjoyment, and (4) Motivation and three independent variables: (1) gender, (2) ethnic, and (3) achievement in mathematics class. Multivariate analysis of variance (MANOVA) were performed by using SPSS.

The linear model was written as,

SC VAL ENJ MOT = G + ETH + ACH + G*ETH + G*ACH + ETH*ACH + G*ETH*ACH

where

SC = Self-confidence

VAL = Value of mathematics

ENJ = Enjoyment of mathematics

MOT = Motivation

G = Gender

ETH = Nationality-ethnicity

ACH = Achievement in mathematics class

Data were analyzed testing for interaction effect and main effect at the .05 level. Data analysis indicated that the three-way interaction effect of the three variables G*ETH*ACH on the four dependent variables Self-confidence, Value, Enjoyment, and Motivation was insignificant (Wilks' Lambda F= .985, $p < .51$,). Hence, it was concluded that there was not enough evidence to indicate a three-way multivariate interaction.

The results also showed that the three two-way interaction effect, G*ETH, G*ACH, and H*ACH, on the four dependent variables Self-confidence, Value, Enjoyment, and Motivation were all insignificant. Hence, it was concluded that there was not enough evidence to indicate a two-way multivariate interaction. Table 1 shows F, p, and eta squared values for the interaction effects.

Table 1

Interaction and Main Effects Tests for SC VAL ENJ MOT = G + ETH + ACH + G*ETH + G*ACH + ETH*ACH + G*ETH*ACH

Effect	Value	F	Hypothesis df	Error df	Sig.	Eta Squared
ETH	.877	2.644	24.000	1658.287	.000	.032
G	.973	3.244	4.000	475.000	.012	.027
ACH	.796	7.021	16.000	1451.787	.000	.055
ETH*G	.939	1.254	24.000	1658.287	.184	.016
ETH*ACH	.830	.986	92.000	1882.602	.519	.045
G* ACH	.953	1.430	16.000	1451.787	.119	.012
ETH*G*ACH	.885	.985	60.000	1856.389	.509	.030

Gender, Ethnicity, and Achievement differences for the four variables were then tested. The data revealed that the effect of Gender, Ethnicity, and Achievement was statistically significant. Table 1 shows F, p, and eta squared for main effects. The eta squared values for Gender and Ethnicity had small effect sizes, and the eta squared value for Achievement had a medium effect size. So, it was concluded that there was enough evidence

to say to say that there was an effect of the variables Gender, Ethnicity, and Achievement on the four dependent variables Self-confidence, Value, Enjoyment, and Motivation. Therefore, follow ups were conducted.

Table 2 shows that the effect of variable Gender to the dependent variables Self-confidence and Motivation was statistically significant. It was concluded that there was enough evidence to say that there was an effect of the variable Gender on the variable Self-confidence and also on the variable Motivation. Table 3 describes that boys scored higher than girls on Self-confidence and on Motivation.

Table 2 shows that the effect of variable Ethnicity to the Self-confidence, Value, and Enjoyment was statistically significant. It was concluded that there was enough evidence to say that there was an effect of the variable Ethnicity on the variables Self-confidence, Value, and Enjoyment. Table 4 describes that Mexican students scored significantly higher than American students on Self-confidence, value, and enjoyment. Students with dual citizenship, students having one American parent, scored higher than Americans on value of mathematics.

Table 3 shows that the effect of Achievement to the four dependent variable was statistically significant. It was concluded that there was enough evidence to say that there was an effect of the variable Achievement on the variables Self-confidence, value, enjoyment, and motivation. Table 5 shows A students scoring higher than B, C, D, and F on all four factors. B students scored higher than C, D, and F students on self-confidence, enjoyment, and motivation and higher than F students in Value. C students scored higher than F students on all four factors. D students scored higher than F students on Self-confidence and enjoyment.

Table 2

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Model	SELFCONF	1448005[b]	60	24133.41	213.719	.000	.964
	VALUE	799938.5[c]	60	13332.31	349.417	.000	.978
	ENJOY	558690.6[d]	60	9311.509	182.665	.000	.958
	MOTIV	141058.6[e]	60	2350.977	117.360	.000	.936
GENDER	SELFCONF	483.267	1	483.267	4.280	.039	.009
	VALUE	108.528	1	108.528	2.844	.092	.006
	ENJOY	126.038	1	126.038	2.473	.117	.005
	MOTIV	226.813	1	226.813	11.322	.001	.023
ETH	SELFCONF	1743.024	6	290.504	2.573	.018	.031
	VALUE	1171.253	6	195.209	5.116	.000	.060
	ENJOY	908.134	6	151.356	2.969	.007	.036
	MOTIV	125.081	6	20.847	1.041	.398	.013
ACH	SELFCONF	11887.46	4	2971.865	26.318	.000	.180
	VALUE	1049.063	4	262.266	6.874	.000	.054
	ENJOY	2408.761	4	602.190	11.813	.000	.090
	MOTIV	892.926	4	223.231	11.144	.000	.085
GENDER * ETH	SELFCONF	346.785	6	57.798	.512	.800	.006
	VALUE	426.922	6	71.154	1.865	.085	.023
	ENJOY	88.105	6	14.684	.288	.943	.004
	MOTIV	61.162	6	10.194	.509	.802	.006
GENDER * ACH	SELFCONF	210.179	4	52.545	.465	.761	.004
	VALUE	109.717	4	27.429	.719	.579	.006
	ENJOY	373.759	4	93.440	1.833	.121	.015
	MOTIV	68.926	4	17.232	.860	.488	.007
ETH * ACH	SELFCONF	3736.377	23	162.451	1.439	.087	.065
	VALUE	981.651	23	42.680	1.119	.320	.051
	ENJOY	1291.705	23	56.161	1.102	.339	.050
	MOTIV	487.727	23	21.206	1.059	.389	.048
GENDER * ETH * ACH	SELFCONF	2261.026	15	150.735	1.335	.177	.040
	VALUE	763.780	15	50.919	1.334	.177	.040
	ENJOY	841.588	15	56.106	1.101	.353	.033
	MOTIV	376.666	15	25.111	1.254	.228	.038
Error	SELFCONF	53976.35	478	112.921			
	VALUE	18238.50	478	38.156			
	ENJOY	24366.45	478	50.976			
	MOTIV	9575.405	478	20.032			
Total	SELFCONF	1501981	538				
	VALUE	818177.0	538				
	ENJOY	583057.0	538				
	MOTIV	150634.0	538				

a. Computed using alpha = .05

b. R Squared = .964 (Adjusted R Squared = .960)

c. R Squared = .978 (Adjusted R Squared = .975)

d. R Squared = .958 (Adjusted R Squared = .953)

e. R Squared = .936 (Adjusted R Squared = .928)

Table 3

Comparison of Means by Gender

GENDER	Self-Confidence	Value	Enjoyment	Motivation
Boys	52.60	38.90	37.35	16.78
Girls	49.43	37.83	36.10	15.02

Table 4

Comparison of Means by Ethnicity

ETHNICITY	Self-Confidence	Value	Enjoyment	Motivation
Mexican	53.16	39.80	32.48	16.49
American	48.57	35.34	29.49	15.19
Dual-National	49.26	38.46	29.59	15.71
Latin American	48.69	36.77	29.33	15.56
European	52.50	39.40	28.33	14.00
Asian	50.46	36.36	29.78	16.29
Other	47.19	36.73	27.70	14.88

Table 5

Comparison of Means by Achievement

ACHIEVEMENT	Self-Confidence	Value	Enjoyment	Motivation
A	61.07	41.05	36.83	18.58
B	53.66	38.70	32.11	16.59
C	46.57	37.38	27.55	13.66
D	43.22	37.16	28.07	12.20
F	35.16	33.44	26.63	10.25

Conclusions

The multivariate data analysis indicated that the three way interaction effect of the three variables Gender*Ethnicity*Achievement to the four dependent variables Self-confidence, value, enjoyment, and motivation was insignificant. The data suggested that there was not enough evidence to say that the three two-way interaction effect, Gender*Ethnicity, Gender*Achievement, and Ethnicity*Achievement, on the four dependent variables Self-confidence, Value, Enjoyment, and Motivation were all insignificant. Hence, it was concluded that there was not enough evidence to indicate a two-way multivariate interaction.

There was enough evidence to say that there was an effect of the variables Gender, Ethnicity and Achievement on the four dependent variables Self-confidence, Value, Enjoyment, and Motivation. Follow ups indicated that there was enough evidence to say that there was an effect of the variable Gender on the variable Self-confidence and also on the variable Motivation. Boys scoring higher than girls on Self-confidence and on Motivation. Table 3 describes that boys scored higher than girls on Self-confidence and on Motivation.

It was concluded that there was enough evidence to say that there was an effect of the variable Ethnicity on the variables Self-confidence, Value, and Enjoyment. Mexican students scored significantly higher than American students on Self-confidence, value, and enjoyment. Students with dual citizenship, students having one American parent, scored higher than Americans on value of mathematics.

There was enough evidence that there was an effect of the variable Achievement on the variables Self-confidence, value, enjoyment, and motivation. A students scoring higher than B, C, D, and F on all four factors. B students scored higher than C, D, and F students on self-confidence, enjoyment, and motivation and higher than F students in Value. C students

scored higher than F students on all four factors. D students scored higher than F students on Self-confidence and enjoyment.

It is important to note that the subjects in this study were atypical because they all attended a private school, were from privileged backgrounds, and from high socio-economic families. The school was patterned on an American high school curriculum and organization, but the majority of students were Hispanic and there were far fewer Anglo and Asian students. Hispanics are usually grouped together in most American research studies, but these Hispanic subjects were comprised of three different groups: Mexican, dual-national (meaning both U.S. and Mexican citizenship), and Latin-American (from other countries in Latin America).

Applications and Implications

If a student's self-perceived ability is critical to success and a predictor of failure or achievement, then concern about students' attitudes must be elevated. Much more needs to be learned about how attitudes are formed and altered, and the best techniques for intervention and stimulation of positive self-efficacy. Consequently, much more must first be done in the development of valid and reliable instruments to conduct the necessary research. Bandura (1981) argued that judgments of self-efficacy are task specific, making them better predictors of success in a particular domain. Therefore, continued research in the area of attitudes toward math is essential if students are to be understood and attitudes altered. The use of a valid and reliable instrument for making determinations about attitudes is a requirement for such research.

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Corporate Source: MID-SOUTH EDUCATIONAL RESEARCH ASSOCIATION Annual Meeting	Publication Date: NOV. 16, 2000

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